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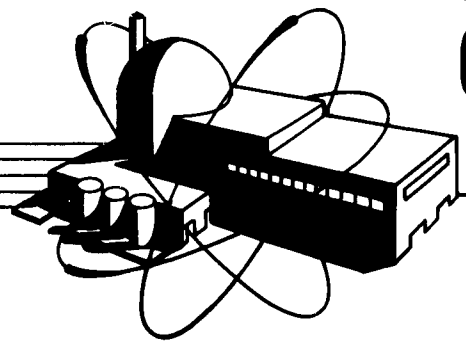
CORPS OF ENGINEERS

U.S. ARMY ENGINEER REACTORS GROUP

NUCLEAR POWER FIELD OFFICE



Operations Support Branch

ARMY—FORT BELVOIR, VA.

Engineer Reactors Group
Corps of Engineers
United States Army

Report OSB 15

Preliminary Investigation of SM-1 Control Rod Seal Failure

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Prepared By
Engineering Support Section

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Preliminary
Investigation of SM-1 Control
Rod Seal Failure

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Approved By:

for LEO J. MISENHEIMER
Chief, Operations Support Branch

18 April 1961

Preface

The investigation of the SM-1 control rod seal failure was initiated as part of the Operations Support Branch mission of reporting ANPP plant malfunctions.

The effort expended in this preliminary investigation included personnel of OSB, Materials Branch ERDL and SM-1 plant personnel.

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SUMMARY

On 26 March, the SM-1 plant experienced excessive control rod drive seal leakage rate. During a vapor container entry for instrumentation check, the leakage rate from each seal was measured. The maximum rate was found to be 6.3 gallons per hour compared to a normal value of approximately .7 gph. Two seals (Rods A & B) were replaced with rebuilt assemblies. This reduced leakage rates to an allowable operating rate. Shim #3 seal was found plugged and back flushing elminated the plugging.

Visual inspection of the disassembled Rod "B" seal indicated leakage increase was due to the increased clearance probably caused by overheating due to loss of cooling water at various times in the operating period.

Definite conclusions as to the cause are not offered until a metallurgical investigation is performed.

I. INTRODUCTION

1. Subject:

This report presents the results of a preliminary investigation of SM-1 control rod seal failure which was identified 26 March 1961.

2. Background Information:

The failure of the control rod seals was detected by plant operations through the increased operation of the seal leak-off pump. This pump normally operates on an off-on basis between high and low level switches on the seal leak-off tank. Normal operation as indicated in the control room on the blowdown recorder chart shows the pump operating less than the period of inoperation. When the seals failed, the pump was found to be operating a longer time period than the inoperative period. During a shutdown for log N chamber trouble, a check of seal leakage rates was made.

II. INVESTIGATION

The plant personnel found the following leakage rates with the primary system at 120 psig and took the following corrective action:

Rod Position	Leak Rate GPH	Action Taken
Safety Rod A	.79	Replaced with rebuilt assembly
Safety Rod B	6.30	Replaced with rebuilt assembly
Regulating Rod C	4.45	Seal assembly ordered
Shim Rod #1	1.01	Seal assembly ordered
Shim Rod #2	.33	None
Shim Rod #3	.22	None
Shim Rod #4	3.18	Seal assembly ordered

In addition, Shim #3 seal was found to be hot from lack of cooling water. This seal was back flushed to eliminate plugged condition. Material causing stoppage was not retrieved although the block was eliminated.

The seal shaft from safety Rod A was removed and replaced. The assembly and shaft of safety Rod B was removed and replaced. A visual inspection of both shafts revealed circumferential grooves worn in each shaft. In addition, the inspection indicated that the contact surface on some of the seal rings had nicks or fissures

through them. Photographs were taken of the parts and are shown in figures 2, 3, 4, 5, 6, 7, and 8. Figure 2 shows the contact surfaces of the seal rings and where applicable the diaphram with which they come in contact. Figures 3, 4, 5, and 6 show close-ups of the two seal shafts in the area where the seal rings and diaphrams are in contact. The four figures show the four quadrants of the shafts. They were rotated 90° clockwise looking from the driven end which contains the Woodruff key. The upper shaft in all pictures is that belonging to the various parts shown and was used to control Safety Rod "B". The lower shaft came from the assembly which drove Safety Rod "A".

The close-ups of figure 3 in the locations of seal rings 10 and 11 shows the initial stages of cracking and swelling with cracking respectively. The cracking is similar to that experienced with fretting corrosion. Rough micrometer readings of the shaft from Safety Rod "B" were made and they are as follows:

Shaft Measurements
Shaft "B"

Location Seal Ring No.	Reading
1	0.626
2	0.627
3	0.627
4	0.627
5	0.627
7	0.627
8	0.625
9	0.627
10	0.627
11	0.624
between 11 & 12	0.627
12	0.627
13	0.627
14	0.626

Additional readings were made at location seal ring 11, these were as follows:

Quadrant 1 - 0.624
Quadrant 2 - 0.627
Quadrant 3 - 0.626
Quadrant 4 - 0.625

During the micrometer reading the swollen material in location 11 flaked off and the surface below was discolored.

III. DISCUSSION

The wear on the shaft and diaphram would indicate that the seal rings rotate rather than float as designed. Since the seal rings slide over the shaft easily, it would be expected that overheating by loss of cooling water to the seals at various times during the 4 yr operating life of the seals caused the rotation of the seal ring due to lack of lubricating water and decreased clearance.

The defects believed to be blistering and cracking (Fig 7 and 8) of the chrome plating at seal ring locations 10 and 11 (Fig 2) could conceivably be caused by overheating. It may be possible that useful life would have been longer if the chrome plating had not been used. It was noticed that the seal rings were only worn on the outboard side where the thrust forced them to ride against the contact surface on the diaphram as designed. Figures 7 and 8 show close-ups of these surfaces. It should be noted that on most seal ring faces there is a groove corroded into the seal ring concentric with the contact surface which is believed to contain crud . There was no obvious wear on the seal ring inside diameter, although some is expected.

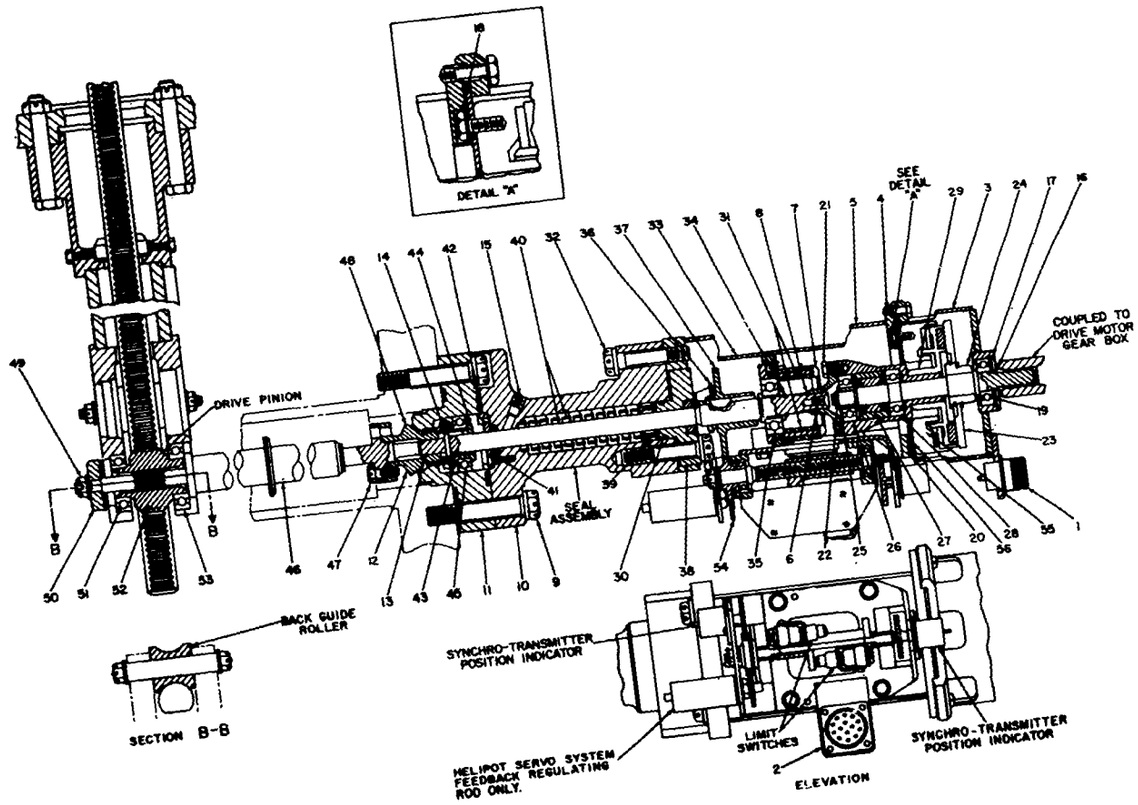
One area which deserves some further evaluation is the failure of the outboard bearing (35-Fig 1)

It is planned to have further evaluation of the wear on the various parts to more firmly establish the cause of failure and possible improvements to extend the equipment lifetime.

The maximum activity level of the shaft is 150 mr.

IV. CONCLUSIONS

There are no specific conclusions being drawn at this time, until the completion of the planned metallurgical investigation by the designers, Alco Products, Inc. A final report on the cause of failure will be prepared after the examination by the designers.



Control Rod and Drive Mechanism

Figure 1

Nomenclature
SM-1 Control Rod Drive Mechanism

1. Receptacle (Mag Clutch)
2. Receptacle (Instrument Pad)
3. Magnetic Clutch Housing
4. Cap Screw
5. Clutch Housing Support
6. Threaded Hole (For Seating Valve)
7. Special Nut (For Opening Valve)
8. Splined Coupling
9. Cap Screw
10. Seal Assembly Flange
11. Valve Housing Flange
12. Valve
13. Splined Coupling
14. Pin
15. High Pressure Connection
16. Retaining Snap Ring
17. Retaining Snap Ring
18. Cap Screw
19. Bearing
20. Brass Spacer
21. Cap Screw
22. Retaining Snap Ring
23. Driving Clutch Plate
24. Hub (Driving Clutch Plate)
25. Spacer
26. Overdriving Clutch Housing
27. Overdriving Clutch Unit
28. Bearing
29. Hub-driven Clutch Unit
30. Seal ("O" Ring)
31. Spacer
32. Cap Screw
33. Clutch Housing Support
34. Retaining Snap Ring
35. Bearing
36. Gear Retainer
37. Gear
38. Packing Gland
39. Lantern Ring
40. Diaphram Seals
41. End Plate
42. Gasket
43. Lock Washer

44. Sleeve
45. Bearing
46. Shaft
47. Cap Screw
48. Valve
49. Slotted Nut
50. Collar
51. Bearing
52. Pinion Gear
53. Bearing
54. Gear
55. Magnetic Clutch Windings
56. Clutch Assembly Retaining Plate

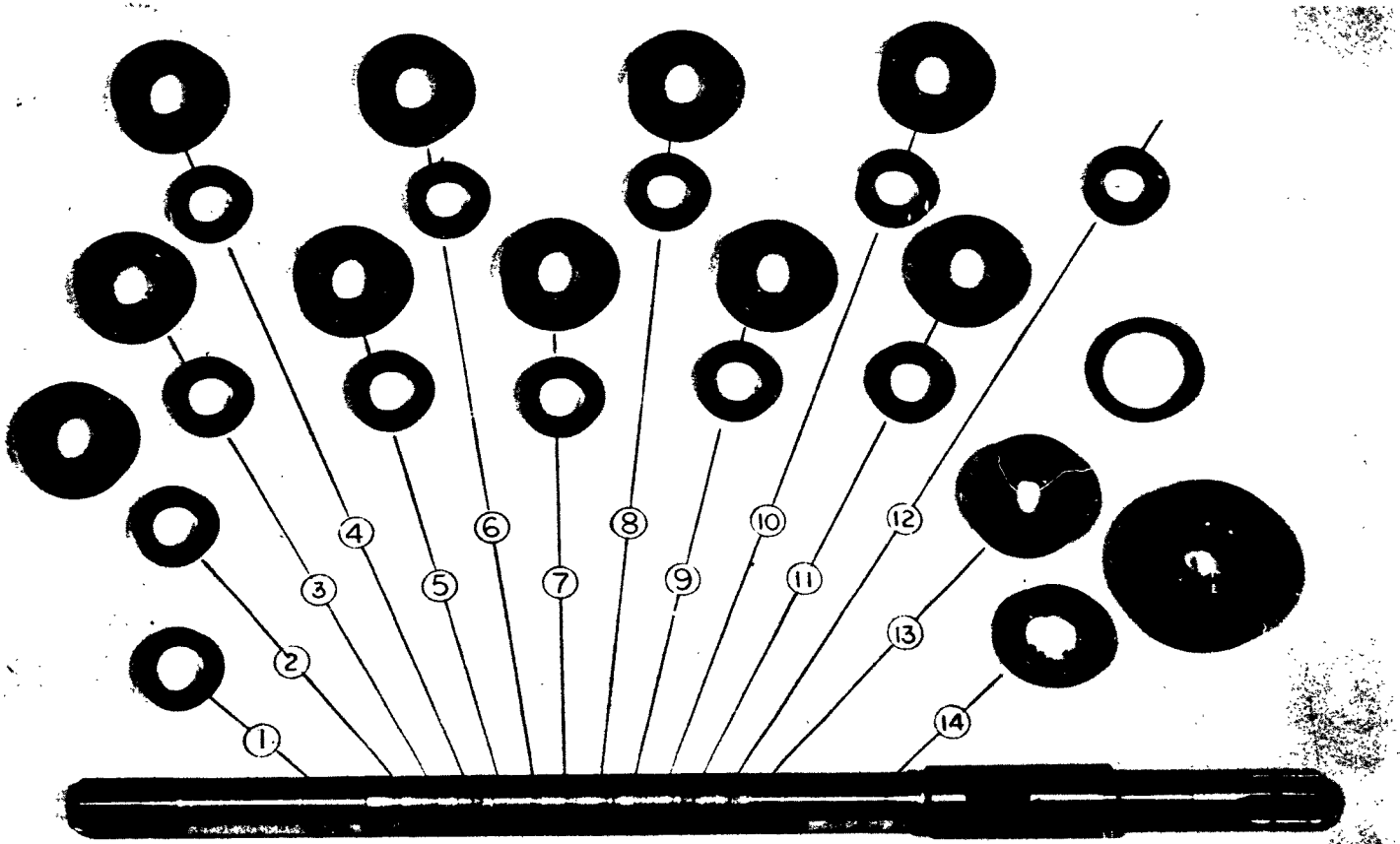
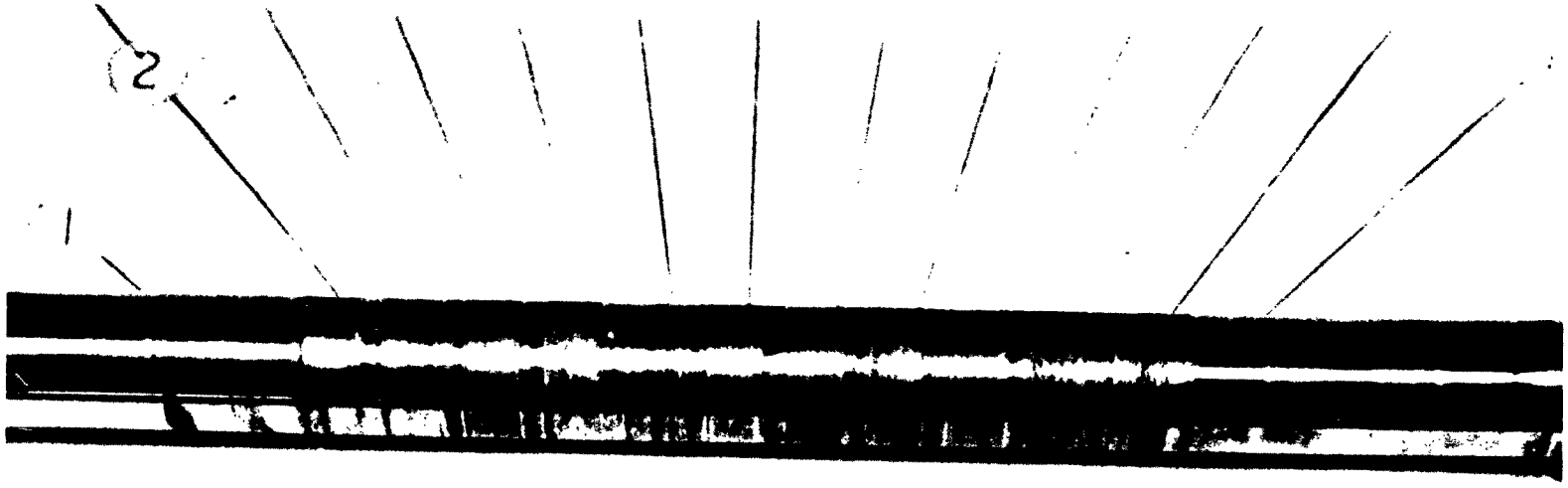
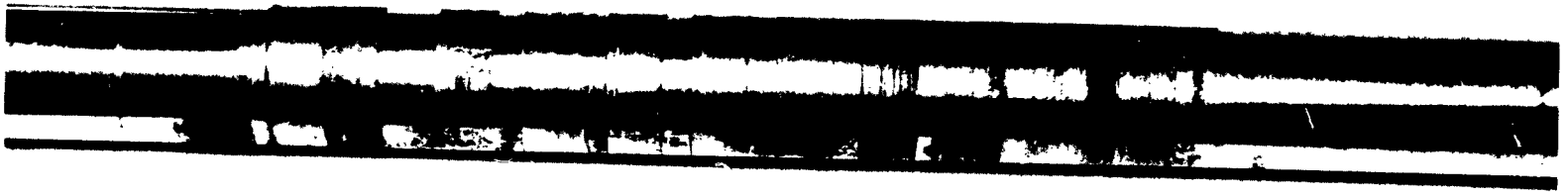


Fig. 2. SM-1 Worn Control Rod Seal Components



CONTROL ROD "B" SHAFT



CONTROL ROD "A" SHAFT

Fig. 3. Quadrant I - SM-1 Control Rods A & B Shafts

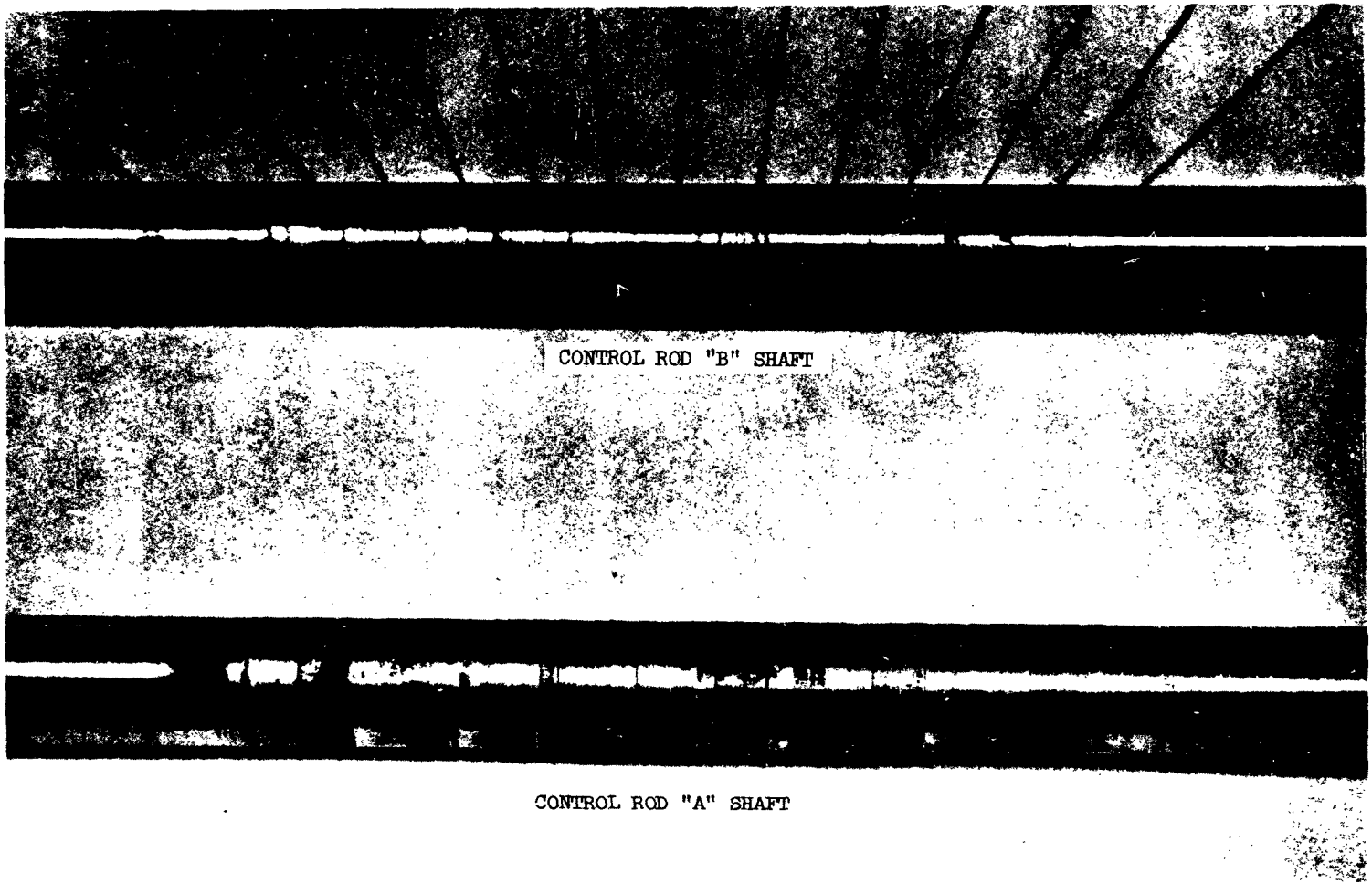


Fig. 4. Quadrant II - SM-1 Control Rods A & B Shafts

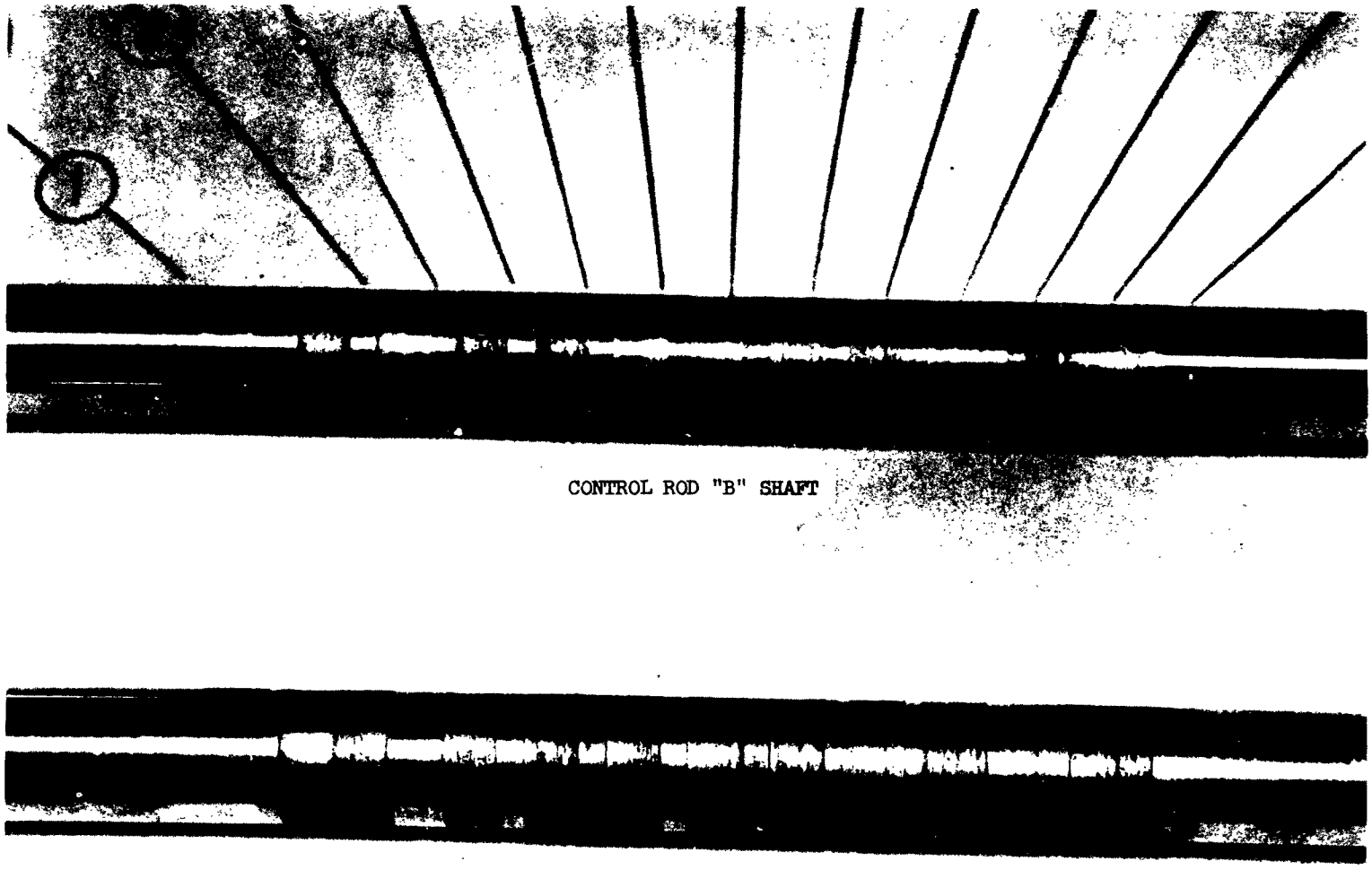


Fig. 5. Quadrant III - SM-1 Control Rods "A" & "B" Shafts

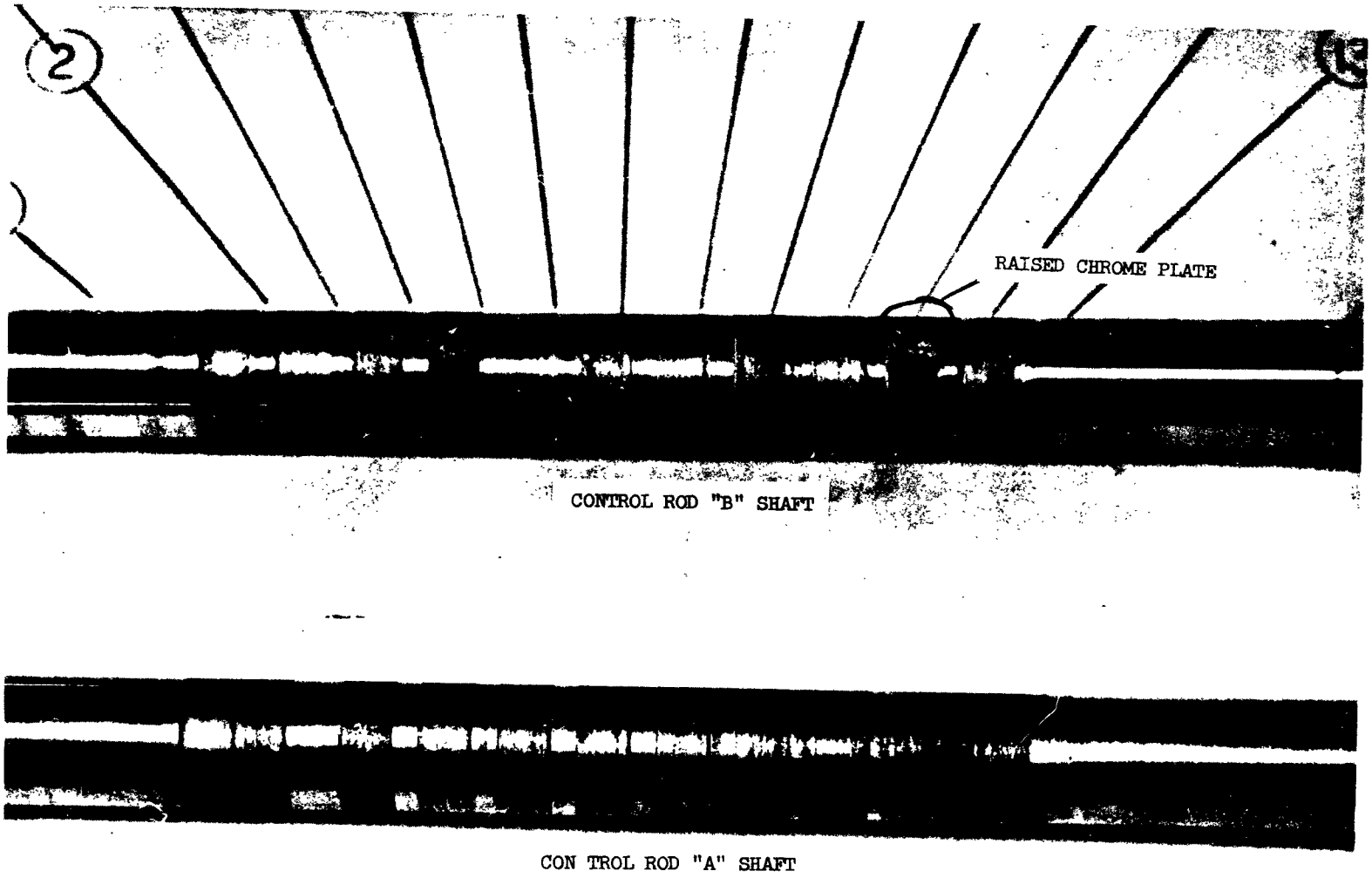


Fig. 6. Quadrant IV - SM-1 Control Rods "A" & "B" Shafts

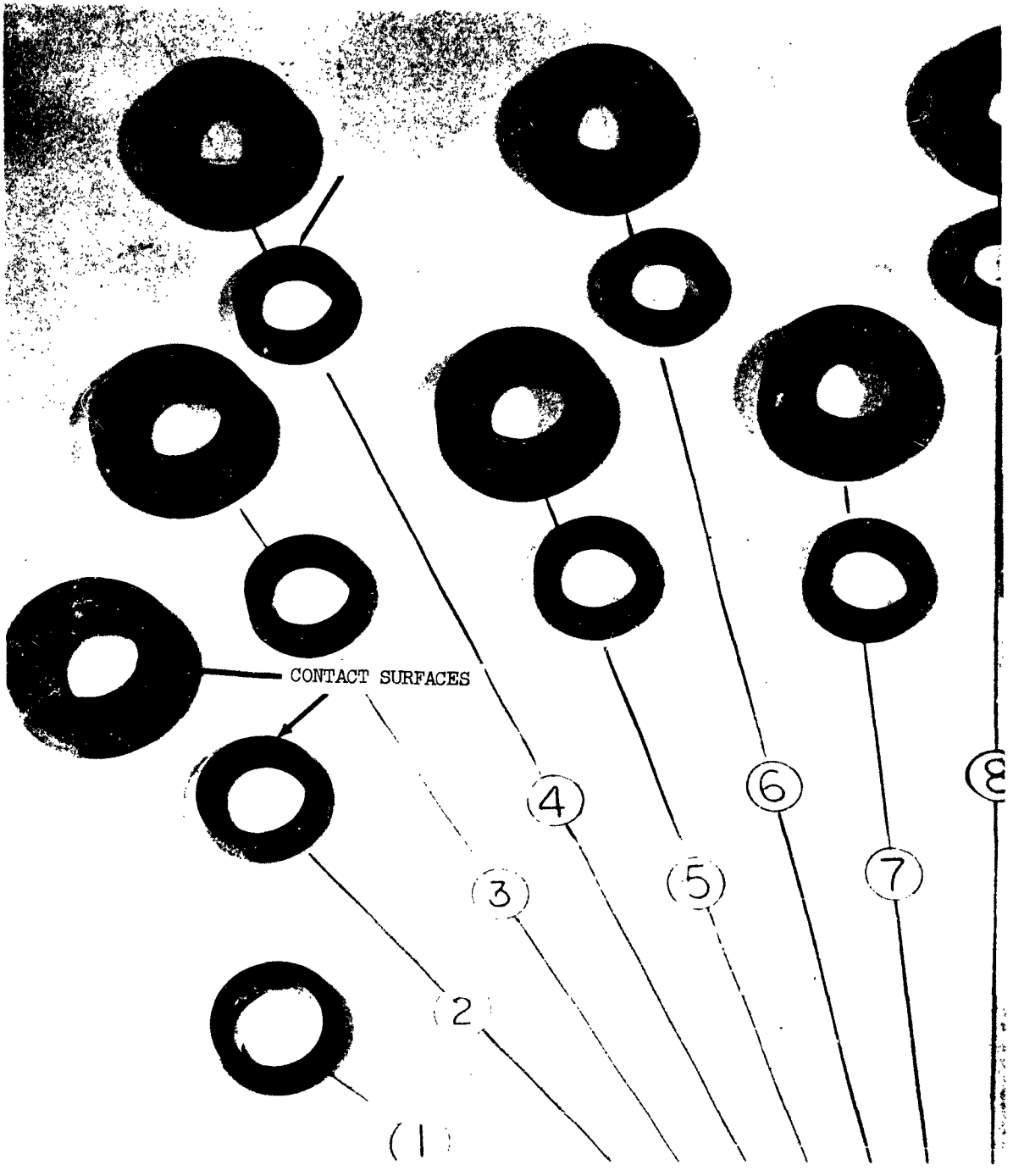


Fig. 7. SM-1 Seal Rings & Diaphragms of Control Rod Seal "B" (1)

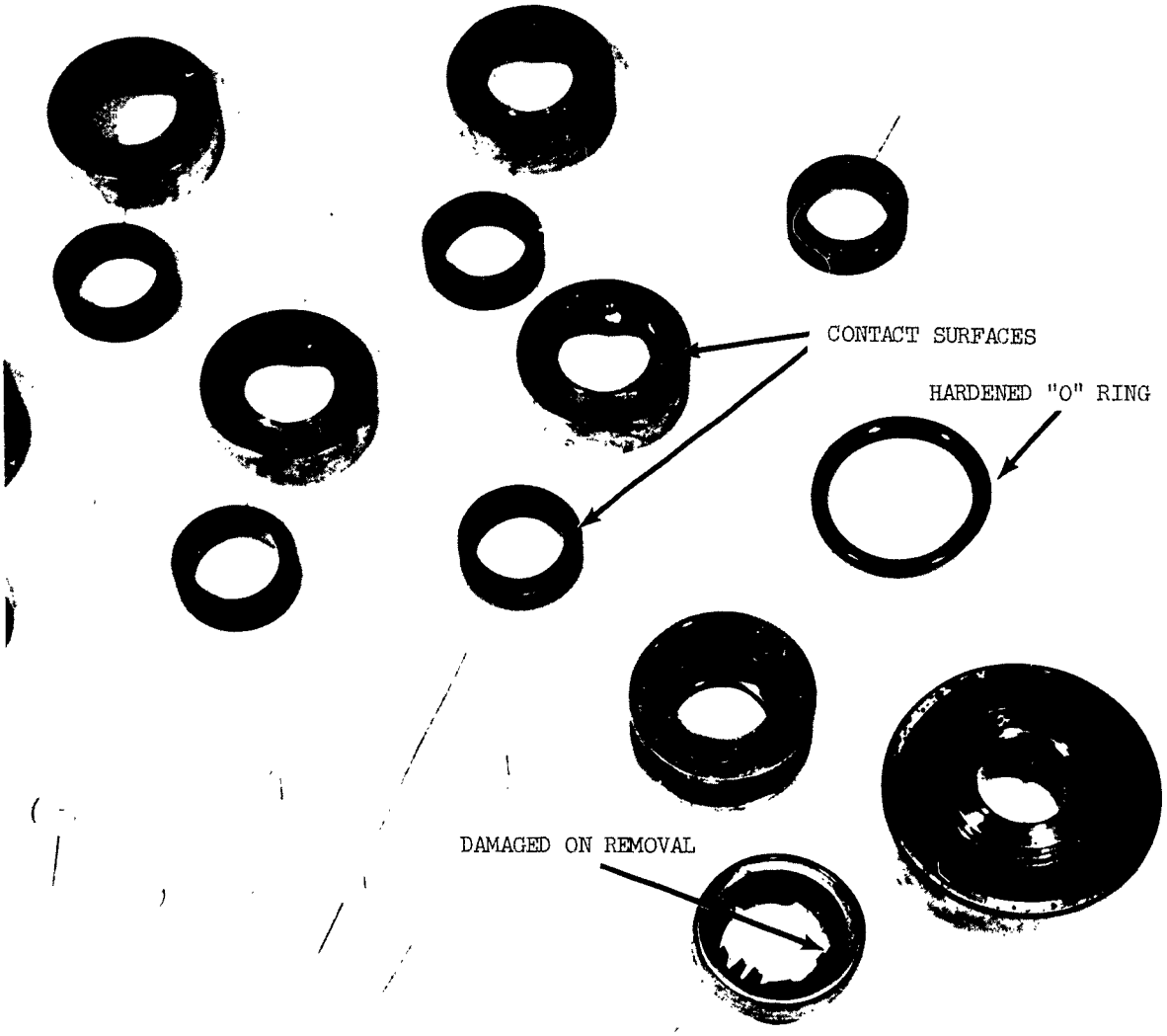


Fig. 8. SM-1 Seal Rings & Diaphragms of Control Rod Seal "B" (2)

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